Wood Opportunities in Non-Residential Buildings

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A Roadmap for the Wood Products Industry

UBC The University of British Columbia Faculty of Forestry

Forintek Canada Corp.

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Forintek Canada Corp. is Canada's wood products research institute providing the Canadian wood products industry and governments with services in research and development and technology transfer.

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Cover photo:

This 109,000 ft² (9,800 m²) wood products research facility houses office, laboratory and industrial activities and was completed in 1990. The structure is wood.

Project: *Forintek Canada Corp., Vancouver, BC*

Architect: *The Hulbert Group*

Structural Engineer: *Jones Kwong Kishi*

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TABLE OF CONTENTS

INTRODUCTION 3

FIRE SAFETY 10

TECHNICAL ISSUES 14

LABOR SKILL 20

DESIGNER SUPPORT 23

WOOD'S IMAGE 26

REFERENCES 30

Five action areas to increase the market share for wood in commercial and institutional construction.

Project: *KidsPeace Recreation Pavilion, Orefield, Pennsylvania*

Architect: *Spillman Farmer Architects*

PHOTO BY STEVE WOLFE PRINTED WITH PERMISSION OF CANADIAN WOOD COUNCIL

INTRODUCTION

THE NON-RESIDENTIAL MARKET

The total value of new non-residential construction in the United States in 2000 was US$292.3 billion — larger than residential construction (17). Although wood is by far the dominant structural material in houses (around 85%), it was estimated to only have about 17% of the non-residential market in 1995 (4). In that year, just 1.5 billion board feet of lumber and 1.2 billion square feet of structural panels were used in the non-residential building sector (12). This is only 10% of the total wood usage in the new residential construction sector, and has declined since 1985 (18).

Building codes are considered one of the largest hurdles to greater use of wood in non-residential construction. Codes serve primarily to protect public health and safety. Because fire is one of the biggest safety risks in buildings, codes apply major restrictions on combustible structural systems. In general, structural wood is only permitted in small, low-rise buildings. While code-related issues are estimated to limit wood's potential non-residential market share to approximately 50% of the value of constructing (4), this still leaves tremendous room for growth. In addition, the 50% estimate is based on model codes prior to the transition in the U.S. to the unified International Building Code, which may open up more market to structural wood applications.

Why is wood used so infrequently as a structural material in non-residential buildings? It certainly is not for lack of knowledge about the material — most American and Canadian building designers are probably familiar with wood. But it is not a *customary* structural material outside of the housing sector; steel and concrete are dominant in the non-residential environment. Change is difficult (the barriers to wood are complex and the building industry is both averse to risk and slowed by inertia) – but with the right focus, the wood industry can make a difference.

The non-residential construction market is an attractive target for the wood industry. It has a construction value even larger than residential buildings but is relatively untapped by wood.

THE HURDLES FOR WOOD

Successful transformation of a market requires familiarity with the structure and subtleties of that market. There have been few studies assessing the market potential for wood products in non-residential buildings. In 2000/2001, Forintek performed a research project involving American and Canadian architects and structural engineers (3), in order to update previous data (9, 12, 15) and to probe deeper into the process and attitudes involved in structural material selection. In this study, architects and engineers identified a number of significant problems limiting wood use in non-residential construction:

1. Fire-related codes are believed to be too restrictive, difficult to meet with wood systems, and often mandate sprinklers for wood systems, which creates further barriers.
2. Steel and concrete seem to offer easier and more cost-effective design solutions.
3. There is inadequate skilled labor in wood, which is acceptable in the residential construction sector but problematic in the non-residential sector.
4. Designers need more training, more familiarity and more support in wood design.
5. Wood is not viewed as an appropriate non-residential material. Although wood is used in countless aesthetic applications, it is perceived to have shortcomings in structural, fire, and durability performance.

NON-RESIDENTIAL BUILDINGS

Non-residential buildings are all those not meant for normal habitation: schools, hospitals, stores, offices, churches, airports, stadiums and so forth. Non-residential buildings are typically larger than houses, and more complicated with respect to design, construction and code requirements. The design and construction team is usually larger and includes design professionals as well as construction labor that is typically more trained than in residential building. In contrast, a home can be built with some unskilled labor and without the services of an architect or an engineer, since the builder can rely on traditional practice and prescriptive building codes.

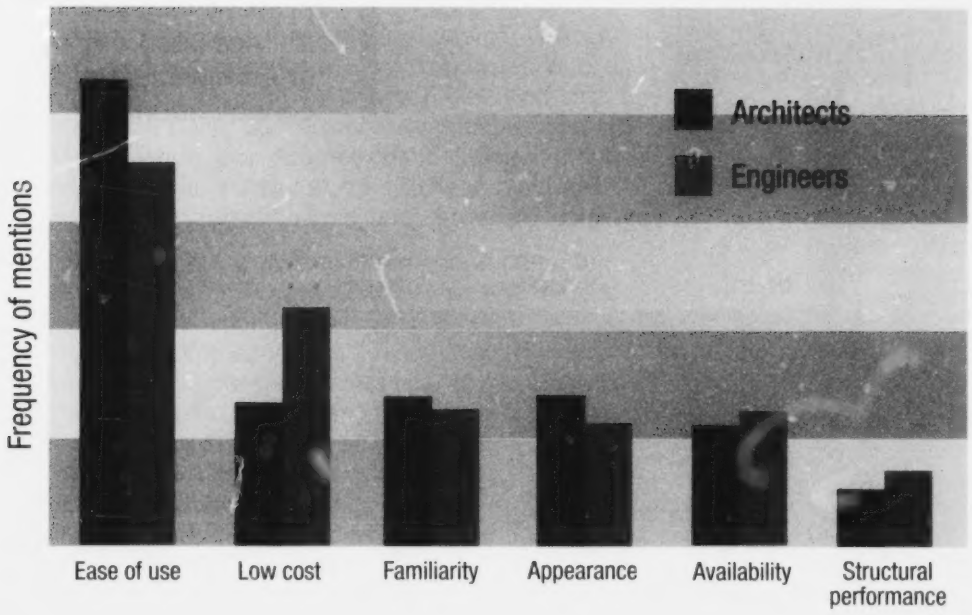
Historically, wood was the dominant structural material in North America for all buildings. Even streets and sidewalks were occasionally paved with wood. But the arrival of steel and reinforced concrete in the late 1800s, among other factors, began to push wood out of non-residential construction. These modern materials were seen to offer technical advantages over wood, including a potential solution for urban fire risk.

PHOTO BY DAVE DAVIDSON PRINTED WITH PERMISSION OF CANADIAN WOOD COUNCIL

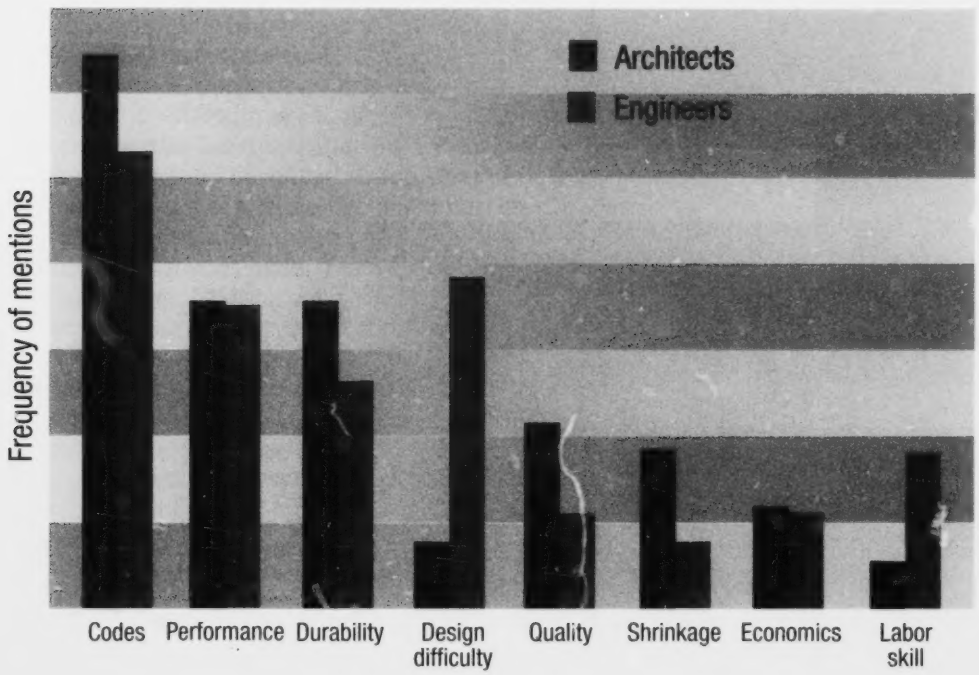
***Project**: Beaverton City Library, Beaverton, Oregon*
***Architect**: Thomas Hacker and Associates Architects*
***Structural Engineer**: KPFF Consulting Engineers*

ANOTHER REASON TO LOOK AT NON-RESIDENTIAL CONSTRUCTION

Steel and concrete continue to challenge wood's dominance in home building. While the steel industry's long-stated goal of a 25% residential market share is still not on the near-term horizon, recent accomplishments in promotion, product standardization, code acceptance and user training are expected to make light-gauge steel more attractive to builders. Meanwhile, concrete is currently the major material in about 15% of homes and growing. Concrete-masonry is the dominant system, but the insulated concrete form system (ICF) is the fastest growing, and — like steel — is boosted by efforts at the U.S. National Association of Home Builders, along with several US federal agencies, to assist in the implementation of wood alternatives in house construction. The concrete industry is also targeting a 25% share within the next few years.

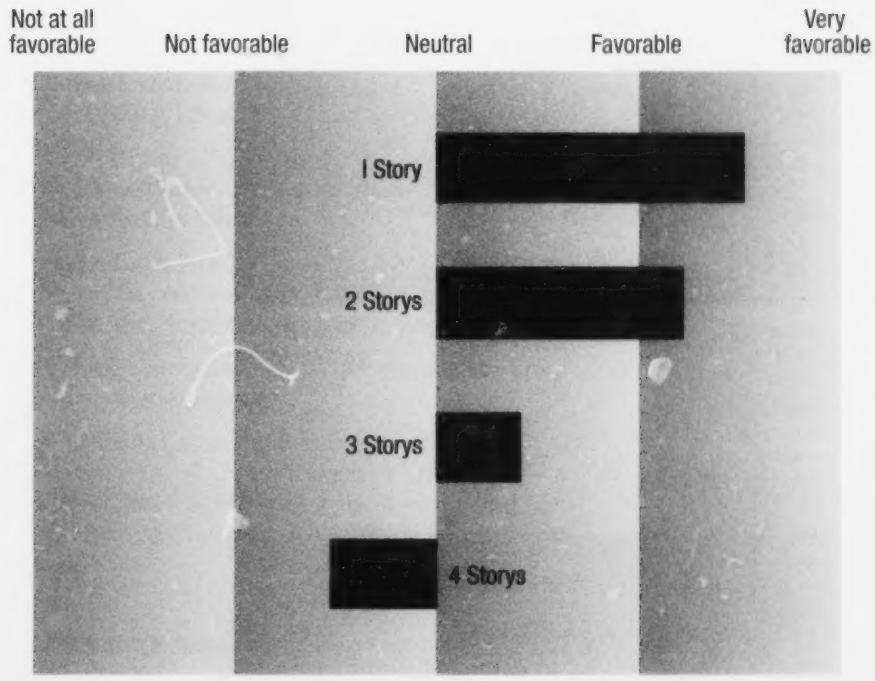


Top six ADVANTAGES of using structural wood in non-residential buildings as listed by architects and engineers (3).

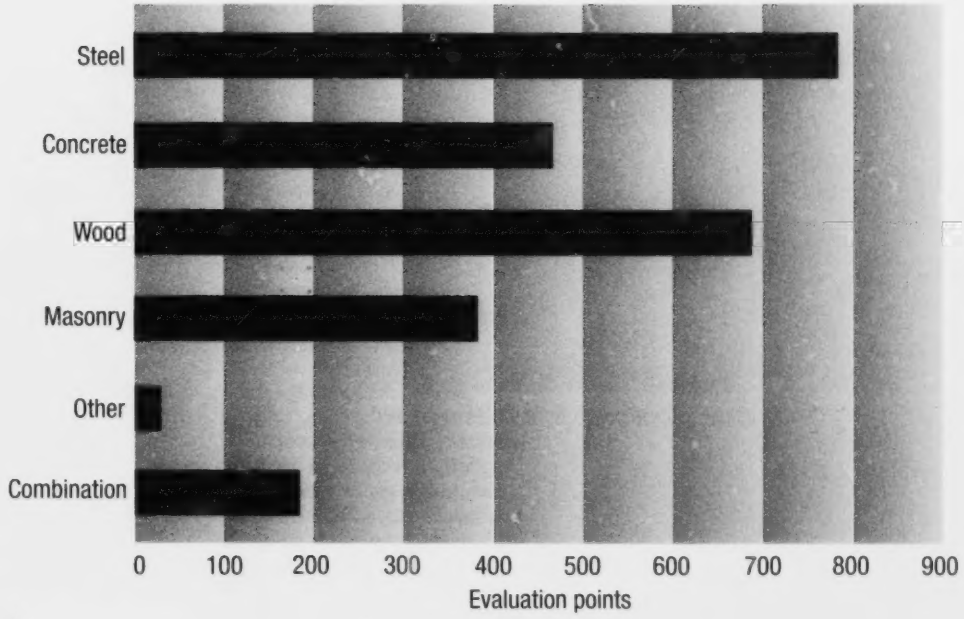


Top eight DISADVANTAGES of using structural wood in non-residential buildings as listed by architects and engineers (3).

Designers generally *like* wood but cite code, technical and cost barriers as the primary reasons it's not used more in non-residential construction.



Favorability of architects and engineers for structural wood at various building heights (3).



Relative preference of architects and engineers for structural materials in low-rise non-residential projects (3).

THE OPPORTUNITIES

A short-term action plan would follow the **path of least resistance** – promoting wider use of wood in currently established applications. For example, wood is already often used in small non-residential buildings with short-span light framing as in residential design. Offices, schools, and restaurants are building types where designers show favorability to wood use, and that are easily framed using conventional techniques and the residential labor pool. Promotional activities should target a greater market share of these buildings, perhaps starting in the more "wood-friendly" regions.

This marketing activity would take the successful image of wood as the best solution for houses and extend it to sell wood as the optimal **small building** solution. All of the economic advantages that wood enjoys in the residential sector (standard materials and methods, plus a large and low-cost labor pool) are easily applied to small non-residential buildings, whose size falls well within the comfort zone for designers to consider wood. Designers may simply need assistance shaking their image of wood as too "housey" for non-residential projects. Small non-residential buildings are also good candidates for greater use of pre-fabricated components. This would help wood compete with other materials with respect to speed of construction and quality control.

Larger buildings present a greater challenge for increasing wood's market share. When loads and spans increase, designers are more hesitant to use wood – they cite code restrictions, cost effectiveness, performance expectations and labor skills as the hurdles. Increasing market share for wood in larger non-residential buildings therefore requires further market study and targeted research and development. Problems to solve include technical barriers, codes and standards gaps, image problems, a construction culture that favors other materials, and educational shortcomings. Change will take time – the construction sector evolves slowly. Small profit margins and tight schedules leave no time or budget for innovation, and the large consequences of failure provide a strong incentive to remain with the status quo. This doesn't mean that wood's chances for growth are low; it means the wood industry needs to apply patience and innovation when seeking entry into a new construction market.

SOME GOOD NEWS: WHAT DESIGNERS LIKE ABOUT WOOD

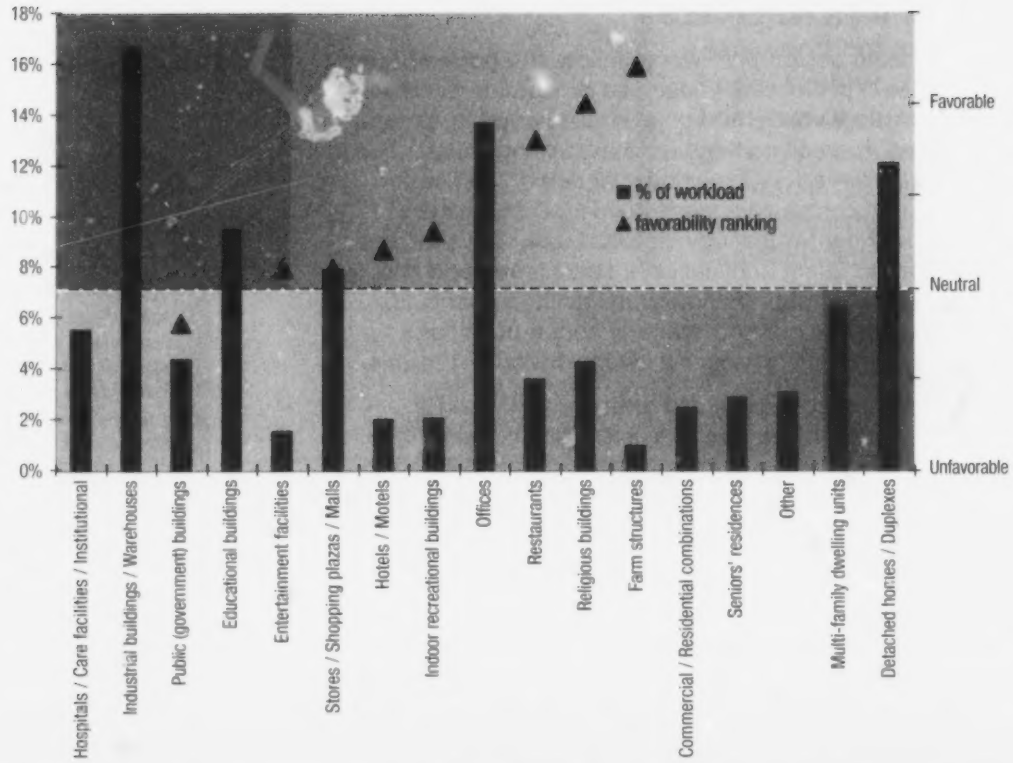
Nearly three-quarters of architects and structural engineers report that they feel comfortable designing with wood in non-residential projects (3). Although significant numbers don't *like* seeing wood used in this context in general, there are some specific building types where favorability to wood is relatively high. Not surprisingly, these are the buildings that have historically often been made of wood: smaller buildings in general, as well as farm structures, religious buildings, restaurants and offices. Designers are favorable to wood in buildings one or two storys in height and less than 10,000 square feet (900 square metres) in area.

Designers say that wood is familiar and easy to work with, has a low cost, and can be assembled by readily available trades. "Ease of use" was rated as wood's greatest positive attribute. Wood also has a higher environmental friendliness ranking than the alternatives (although by a small margin due to forestry concerns). Wood's appearance is a positive attribute, at least in those buildings where the structure is exposed for aesthetic affect.

Project: *Christ Church, East Greenwich, Rhode Island*
Architect: *Newport Collaborative Architects*

PHOTO BY AARON USHER III PRINTED WITH PERMISSION OF CANADIAN WOOD COUNCIL

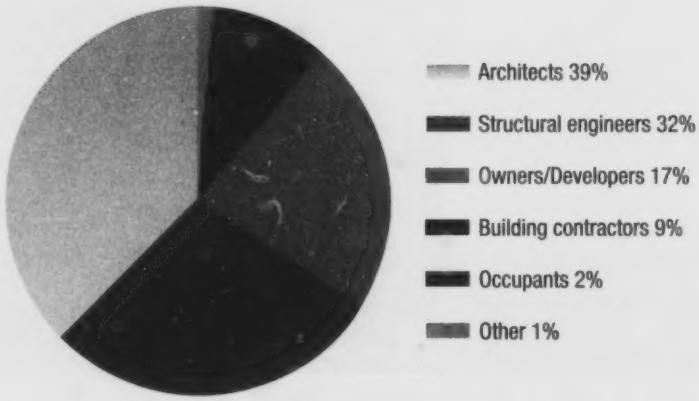
Favorability of architects and engineers for structural wood in various building types and per cent of their workload devoted to those types (3). Stores and offices are the best bets for wood, as they have both a high percentage of designer workload and a good favorability ranking for wood.



WHO SELECTS STRUCTURAL MATERIALS?

In a non-residential project, the design and construction team is typically large, multidisciplinary, and knowledgeable. Any of the players — especially owners, architects, engineers or contractors — can have an effect on design decisions. In a traditional model, the owner hires the architect, who is responsible for the project and the rest of the team. However, owners frequently depart from this model, taking on greater involvement in decision-making, as well as maintaining a more direct relationship with the builder. The owner-builder combination sometimes overrides the recommendations of the design professionals. In addition, project specifics such as schedule, occupancy scenarios and the bid process all affect the decision-making roles of various team members. Overall, in a non-residential project, the decision-making machine is variable, complex and difficult to describe (7, 10).

As with many design decisions, the selection of structural material probably has multiple influences. Only 27% of architects and engineers feel that this choice is made by a single individual; the remainder believe that material selection is a multidisciplinary process (3). However, the team players may not truly be selecting material if the choice is essentially pre-determined based on precedent or availability. Traditional practice, builder preference, product cost and speed of delivery are probably the most influential factors in material selection.



Average influence of various parties on the selection of structural materials, according to North American architects and engineers (3). Although 27% believe the choice is made by one discipline, 73% consider it to be a multidisciplinary decision, with influence weighted as shown in the graph.

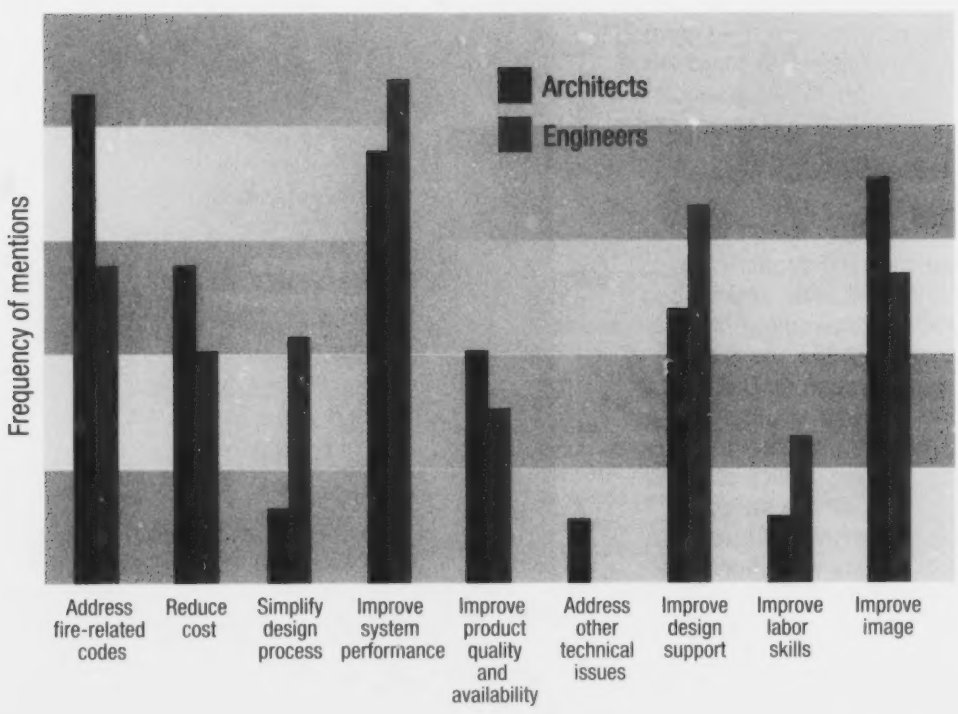
BEST BETS

- **It's not just for houses – market traditional light-frame wood construction as the optimum *small building* system.**

- ***Larger buildings* are different. First, obtain more thorough market intelligence to guide R&D. Then develop high performance systems that are cost-competitive with steel and concrete. Simultaneously embark on an image campaign to promote an acceptance of wood in non-residential construction.**

Project: *Coal City Middle School, Coal City, IL*
Architect: *Legat Architects*

PHOTO BY MARIUSZ MIZERA PRINTED WITH PERMISSION OF CANADIAN WOOD COUNCIL



What architects and engineers feel needs to happen for structural wood use to increase in non-residential buildings (3).

1 FIRE SAFETY

WHAT THE DESIGNER IS SAYING

Building codes, which generally focus on life safety, often impose more restrictions on the use of wood-based building materials in construction of non-residential buildings than on competing materials, due to concerns over fire safety. The use of wood as a structural material is usually restricted to low-rise buildings of limited floor area, and is frequently accompanied by requirements mandating the installation of automatic sprinkler systems for added fire protection, where otherwise, such systems may not have been required.

Not surprisingly, architects and engineers suggest that building code restrictions related to fire safety constitute the number one barrier to greater use of wood in building construction, and this topic is their principal suggestion for where changes need to happen in order for them to use wood more often in non-residential construction (3). In addition to the explicit code prohibitions on combustible construction, design professionals also mention the complexity of meeting code requirements related to the fire resistance of wood-based structural systems, lack of choices among listed and other pre-tested fire-resistance-rated wood construction systems, and the added costs associated with installation of sprinkler systems in buildings, and particularly in wood buildings.

A standard fire resistance test for an assembly (in this case, a 2 x 10 wood joist floor with gypsum board ceiling), conducted at the National Research Council Canada.

OUR INTERPRETATION

Many in the wood industry feel that the restrictions on use of wood by building codes and local ordinances are overly conservative. One major stumbling block is simply the use of the term "combustible" as a basis for classification of construction systems. This term automatically impedes the use of wood and unfairly identifies wood buildings as posing a greater hazard to the public, regardless of the actual ability of wood buildings to provide adequate levels of fire safety. Because building codes generally limit wood use to small buildings of limited height, many specifiers feel that wood design is prohibited for most buildings.

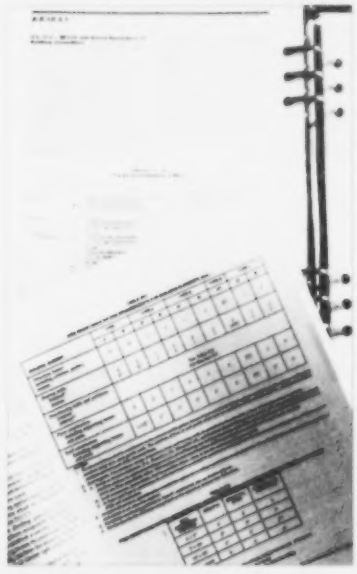
One assessment of model building codes in the U.S. typically found a maximum allowable area of

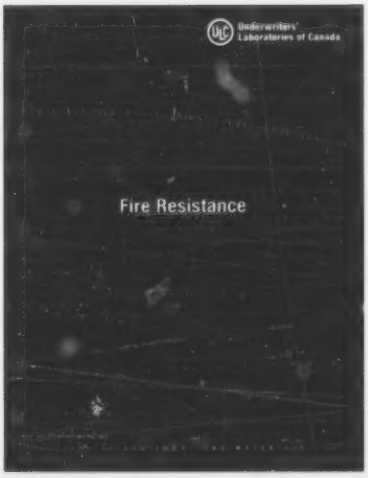
"In most applications where we don't use wood, it is because combustible construction is not allowed in the building code or sprinklers are required."

30,000 square feet per floor for wood buildings without sprinkler systems (4). Allowable areas go up significantly (in many cases doubling or tripling) when sprinklers are installed. However, sprinklers are perceived to add cost and complexity to a wood design project. This explains the study's finding that wood is far less likely to be used in projects requiring sprinklers.

Although there are substantial restrictions on the use of wood in construction of non-residential buildings, these restrictions are estimated to only limit wood's potential market share to about 50% of the overall non-residential building construction market. Given that wood's share of this market is far less than that, there is clearly a large missed opportunity for more market-share without necessarily making any of the changes to the codes suggested by design professionals. Instead, the problem may be solved through **education or promotion** – designers and building officials may not have a full understanding of how to design wood buildings for code compliance, may not realize that many buildings can be designed to meet those code requirements using wood, may need help in interpreting the fire-safety provisions of the codes, and may hold misconceptions regarding wood's ability to deliver fire safety.

Public conjecture about wood and fire safety tends to run ahead of the research community. For example, on-going questions regarding the fire performance of engineered wood products have led to restrictions on their use and even their outright ban in some jurisdictions. One solution to this problem – and to designers' complaints that there aren't enough fire-resistance-rated wood assemblies available – is to **continue conducting standard fire-endurance tests** for products or systems that are currently missing from published test data. Having a complete catalogue of fire-resistance-rated assemblies and providing assistance to designers about how to use those assemblies to meet code-mandated requirements





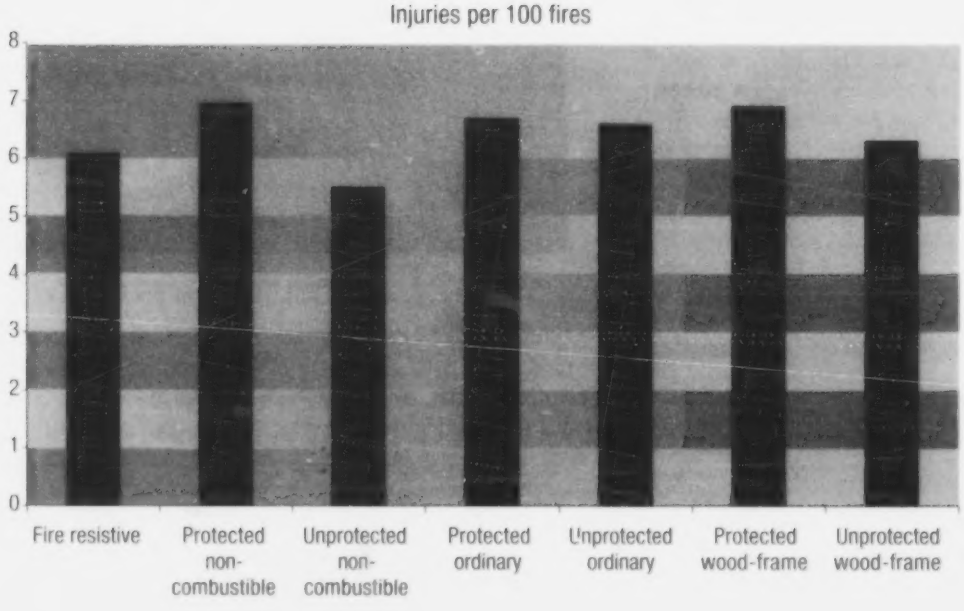
Building codes tell designers the required fire-resistance ratings for various parts of the building under design. Designers then turn to various catalogs and handbooks to find design details for assemblies that will meet those required ratings. Rated assemblies are published in these listings after undergoing standard laboratory fire tests.

are necessary actions within the current prescriptive building code environment.

Misconceptions about wood and fire safety are also countered through greater promotion of **fire-loss statistics** comparing fire safety in wood buildings to that in non-combustible construction. Because much of this data shows wood construction in a very favorable light, it can support the image-control activities discussed in Chapter Five.

As codes move towards performance-based design, the wood industry needs to continue preparing for the technical requirements associated with that change. Performance-based codes are currently being adopted around the world, and many countries are far ahead of Canada and the U.S. in this process. In those countries, fire performance research is moving vigorously to meet the technical demands of performance-based design (1) and to produce the design tools used for that kind of building code environment. North American research into the fire performance of wood building systems must remain ahead of the impending code changes on this continent if the industry is to be positioned for the change.

Performance-based codes offer a real opportunity to increase wood's market share in non-residential structural materials – if we're prepared before they arrive.



FIRE SAFETY DATA

It's important to generate valid statistics on actual safety in wood-frame buildings, to counter the misconceptions and stigma associated with the word "combustible." Shown here are estimated average rate of injuries per 100 fires in low-rise apartment buildings in the U.S. from 1982-1996, by construction type. "Fire resistive" means all major structural assemblies are made from non-combustible (i.e., not wood) materials, and assemblies typically have at least two-hour fire-resistance. "Ordinary" means the exterior walls are masonry; interior walls, as well as floors and roofs may be combustible construction. "Protected" means that the major structural assemblies have a minimum one-hour fire-resistance rating. Clearly, injuries don't substantially vary as a function of construction system. This is because building contents and other factors are more important to life safety than the type of structural system. Source: U.S. National Fire Protection Association.

The major technical requirement for the wood industry is to develop the ability to use computer **models to predict the effects of fire in buildings**, including fire growth, fire endurance, and thermophysical effects of heat and fire on wood structural systems. Models are needed to demonstrate the fire performance of building designs, and to demonstrate that the levels of fire safety being provided by building designs meet the objectives of the building codes (2). Without such predictive models, a designer can only estimate the performance of a proposed design solution and cannot, in any practical fashion, demonstrate its compliance with the objectives of the code. The potential benefits to wood from performance-based codes are substantial, as they would, in all likelihood, remove existing height and area restrictions on wood structures and the stigma attached to "combustible" construction.

Currently, the issue of sprinklers is in flux as more and more regulatory bodies and insurers are mandating that automatic sprinklers be installed in all non-residential buildings, regardless of construction type. While this seemingly levels the playing field for wood systems, in fact a market barrier still exists – there is a considerable lack of knowledge about how to efficiently and effectively sprinkler wood-frame buildings. **Better sprinkler technologies, installation techniques and sprinkler design standards** need to be developed for non-residential wood construction.

BEST BETS

- **Help designers with code compliance.**
- **Help designers with sprinklers.**
- **Address misunderstandings about wood's fire safety.**
- **Fast-track development of fire performance models.**
- **Continue work in determining fire-resistance and sound-transmission-ratings of generic wood assemblies.**

2 TECHNICAL ISSUES

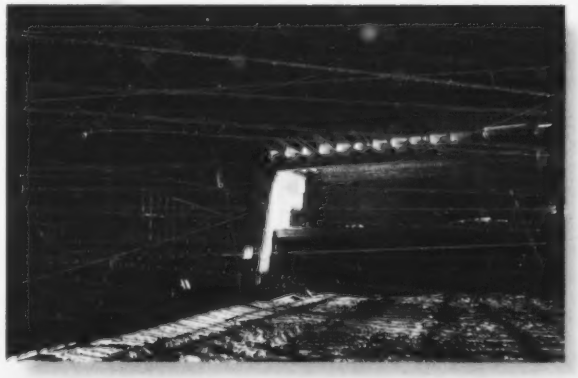
WHAT THE DESIGNER IS SAYING

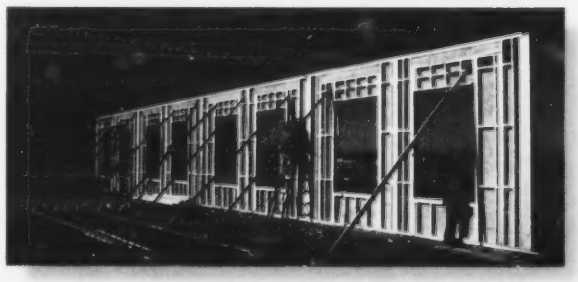
For many non-residential design situations, wood isn't considered to be a reasonable structural alternative to steel and concrete. Whether perception or reality, many North American architects and engineers believe that structural wood systems are unable to deliver adequate technical performance at a competitive total cost compared to the alternatives. Cost is the main problem, even among end-users favorable to the material: "Many owners and contractors prefer wood, but costs are a deciding factor."

This is most true for long-span structures, where steel is often considered more cost-effective than wood. In addition, those types of buildings are time-consuming to engineer in wood: "We do not make money designing in wood due to complex detailing issues." More designer support would help, as discussed in Chapter Four, however, technical solutions such as off-the-shelf connections, pre-engineered systems and more design data for wood systems are even more important for saving the engineer time.

Many designers cite a variety of structural concerns about wood. Span limitations are the most frequently mentioned, along with greater beam depth required for a span in wood versus steel or concrete. Other comments suggest a lack of confidence in wood's general strength, its ability to withstand lateral loads and its degree of stiffness.

Non-structural technical concerns include low fire ratings for wood assemblies, design difficulties and costs associated with sprinklers, durability against biodeterioration, perceived life spans of wood buildings, and overall quality of wood products, which is generally thought to be in decline. Where fire, durability, longevity or floor serviceability concerns are important, concrete is typically the dominant material.





Non-residential structures often have taller walls, longer spans and greater performance expectations than houses — and we are missing some of the technical information on wood needed to help designers.

OUR INTERPRETATION

Steel and concrete systems are easier to design because they are sitting on a strong foundation of research and performance data, which in turn has led to inclusion of numerous systems and connection details in building codes, standards or design guidelines. This means that a structural engineer has all of the information and tools at hand to quickly and confidently design any number of system types with steel and concrete.

This is not yet the case with wood. Other than for the standard residential platform-frame system, there are a limited amount of research data and virtually no design guidelines for equivalent wood-based systems. The result is that an engineer using wood typically has to do more engineering design work without more pay. It also means wood is not well-positioned for performance-based design codes that will be introduced in the near future.

Wood is somewhat behind steel and concrete in these technical areas simply because, as our traditional

CONNECTIONS

How structural elements meet is a critical part of engineering. This is especially important in structural systems where loads at the joints are large, as in heavy timber structures and most steel and concrete systems. The role of the connection is to join pieces together and safely transfer the load from one element to another. Except for monolithic concrete joints and traditional timber joinery, all other connections involve additional elements: nails, screws, bolts, rivets, plates, hangers, anchors, rings, welds, or glue. Designing a connection to withstand the specified loads is a complex issue that may be additionally burdened by buildability issues and aesthetic concerns. The steel industry has solved this problem by providing standard connection details and a variety of off-the-shelf standardized hardware for different load levels and member sizes. The wood industry has not yet matched this design convenience, but ***should***, according to engineers.

Project: *UBC Forest Sciences Centre, Vancouver, BC*
Architect: *Dalla-Lana Griffin Dowling Knapp*
Structural Engineer: *CWMM Consulting Engineers*
Timber Contractor: *Timber Systems*

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residential material, its use is guided by conventional practice. In other words, a house can be designed and built without the involvement of an architect or engineer – the house has been essentially pre-engineered, because the builder follows prescriptive building codes. Since most wood goes into residential construction, there hasn't been a strong push to develop any further technical information about wood.

By contrast, non-residential construction typically requires engineering design. Engineers have technical information needs that are already well-met with respect to concrete and steel. If wood is to compete in engineered building applications, further research and development is needed to fill the technical gaps for wood.

The R&D program should include attention to the **light-frame** structural system, as there is good potential for quick market gain in building categories like small offices, shops and schools. Although this is a fairly well-understood wood system, light-frame in wood may not be a simple scale-up of residential framing. For example, non-residential walls are generally taller and floor/roof spans longer than in houses.

Larger buildings requiring **long spans** and large open areas are currently dominated by concrete and steel and are a tougher sell for wood, primarily due to cost and precedence factors. However, this is a tempting market segment, as a large percentage of non-residential construction falls into this category. Wood is capable of meeting most long-span needs in either light-frame (trusses) or in heavy timber (glulam beams, heavy timber trusses, etc.), however, cost-competitive systems need to be developed and possible misperceptions addressed (Chapter Five). This may have particular benefit for increasing the usage of exposed heavy timber construction, which already enjoys a favorable aesthetic image but is frequently disadvanted by costs. New long-span systems in wood that can improve the span-to-depth ratio would also help for multi-story buildings.

Hybrid systems and products, where wood is used in combination with other materials, offer good potential, but further research work is required to deliver design data for such systems. Innovative hybrid products, such as fiber-reinforced glulam beams, offer potential for substantial improvements in strength and stiffness properties, but success depends on a good basis in analysis and design, in addition to other considerations (6). Another form of hybrid construction is the combination of different material systems within the same building, already accepted as common practice. For example, concrete masonry walls paired with a wood roof is a popular combination beneficial for both materials, as concrete masonry does not have a roof solution of its own, and wood may have been excluded

THE BIG BOX

This building type comprises a large segment of the non-residential market and is popularly constructed as a pre-engineered and pre-fabricated metal building. Designers suggest that wood has some significant technical and cost issues to address before it can compete in this category.

What designers want:

"Capacity for higher loads and longer spans."

"Better connections."

"Cost-effective systems-related assemblies."

"Resistance to decay."

"More engineered wood products."

"Better quality material."

"Improved floor systems."

"Solve acoustics/sound-transmission issues."

"More pre-fab/pre-cut components."

"Improved dimensional stability."

from the exterior walls for code or other reasons. Wider use of these hybrid buildings would be assisted by better technical understanding of issues such as connections, dynamic loading and so forth.

Connections for both heavy timber and hybrid systems require technical study and product development to address a frequent complaint of engineers regarding wood systems: "The design of a member is relatively easy compared to the design of a connection and the fabrication of connector plates." There are substantial gaps in the knowledge base on connection performance, in spite of renewed research interest due to expansion in the development and use of engineered wood products (13). Simplifying connection design will help capitalise on designers' favorable inclination towards engineered products - 52% intend to use more engineered wood products in future work (3).

Durability of wood systems is a frequently-raised concern among designers, which requires solutions with respect to preservative treatment of solid and engineered wood products and better guidance to designers in building envelope design. For building applications at risk of attack by termites or fungi, there does not yet exist a full range of treated engineered wood products. Designers also believe that wood delivers a shorter service life than steel or concrete, a perception that probably has little to do with biodeterioration risk, but rather reflects cultural associations with certain structural materials. Research into actual building service lives can serve to counteract this perception.

The engineering of wood systems for **high wind** loads requires special attention, particularly in the eastern United States. Hurricane Andrew in 1992 was a benchmark event that led to stringent wind-resistance code requirements and insurance industry responses, both of which resulted in some barriers for wood. New code requirements place a greater emphasis on the need for stiffness, which favours concrete. To compete, wood systems need to resolve some technical and cost issues: "It's difficult to provide a good stiff building in wood." "We need standard manufacturer details for hurricane-resistant design."

While wood construction has demonstrated good **seismic** performance in the past, increasing code requirements in the western part of the U.S. and Canada have led to a need for further research. Deformation and energy absorption characteristics of wood connections and systems must be investigated and codified.

Stiffness characteristics also affect some perceived shortcomings of wood **floor** systems and the issue of **serviceability**: "We need recommendations for stiffer floors in office buildings." Serviceability describes the

BEST BETS

- **Continually gather market intelligence as an on-going guide for R&D.**
- **Provide performance data to support the development of new design standards and guidelines for various wood-based structural systems.**
- **Standardize connections for wood-based systems and provide more off-the-shelf products.**
- **Develop design data for connections and systems using wood in combination with other materials.**
- **Standardize design data for engineered wood products to enable product-to-product comparison.**
- **Standardize testing and code development procedures.**

WHY NOT WOOD?

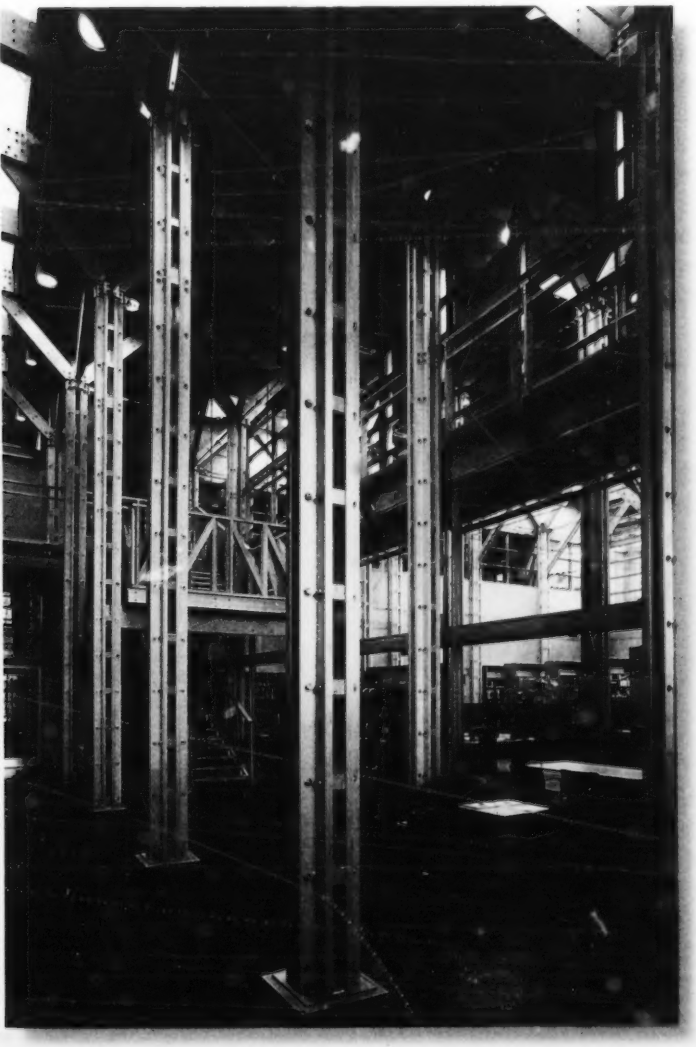
Steel "trees" in the Vancouver airport? A heavy timber structure may have been more fitting for this gateway to some of the world's greatest forests. It's likely that costs, building codes and product availability were the main reasons for not using wood, but technical design hurdles may have been a factor as well. This structural system is a braced-frame type, for which current steel design guidelines contain complete design and detailing information. This makes it relatively easy for a structural engineer to execute the architectural intention in steel. The same design in wood is technically feasible but difficult to implement, as corresponding design details and connection capacities are not included in current wood design guidelines. The result is additional engineering work if wood is chosen over steel or concrete, which increases project time and costs and which would most likely require a wood design specialist.

Here's a common building type — three floors of wood-frame condos over ground floor storefront retail. Why is the ground floor concrete? One reason is the large openings for shop windows, which an engineer typically resolves using a structural system known as a moment-resisting frame. This system is easy to execute in concrete or steel — an engineer can consult design guidelines and find all the necessary information. We currently have no practical solution for a moment-resisting frame using wood.

Wood needs to reach the same technical level as steel and concrete in the eyes of design professionals.

extent to which a structural system carries a load safely and without excessive deflections, vibrations or other undesirable performance side effects. Related concerns about wood floors include adequate acoustic separation and fire separation between floors.

Both fire safety engineering and structural engineering are moving towards an environment of **performance assurance** in light of upcoming performance-based codes. Engineers may also need to demonstrate the expected building performance for the sake of insurance providers and building owners. Thus, performance models are increasingly sought by engineers, whose characterisation as a risk management discipline is becoming even stronger (2). And engineers need predictive performance tools to manage their own risk: "We have to ensure no future liability."



PROPRIETARY DESIGN DATA

As a group, engineered wood products are characterised as having a high degree of proprietary data compared to competing materials. For example, while an engineer working with steel or concrete can typically use generic information in design calculations, she has to rely on the manufacturer's own data with many engineered wood products. Engineers often prefer generic data, as they are accustomed to this type of source, the data is standardized to enable easy comparisons and use, the data comes from a single source, and the data has been subjected to rigorous review.

PRE-ENGINEERED COMPONENTS: TIME-SAVERS FOR THE DESIGN TEAM

Trusses – a pre-eng, pre-fab success story for wood. Can we do it again?

Innovative columns composed of small members of laminated veneer lumber are supporting the roof over the reception area of a laboratory building. Labor-intensive as a unique design solution, components like this could be pre-engineered and pre-fabricated.

Project: *Forintek Canada Corp., Sainte-Foy, QC.*

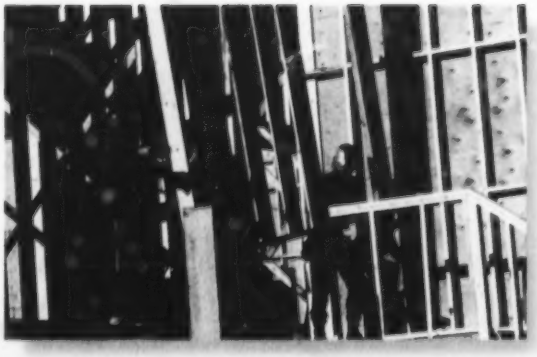
Architect: *Gautier, Guité, Daoust et Lestage.*

Engineer: *Les Consultants BPR.*

3 LABOR SKILL

WHAT THE DESIGNER IS SAYING

A lack of skilled and knowledgeable wood tradespeople has a substantial effect on an engineer's confidence: "The reputation that stick framers have in our area is not conducive to an engineer specifying wood products. Anybody with a hammer can call himself a framer and louse up a design. I think certification much like welders would help". Comments about the poor availability of skilled wood labor cross all geographic areas of North America, and the problem seems particularly severe in the United States. Residential construction practice in North America is highly tolerant of unskilled labor – the structural redundancy and large safety factors inherent in prescriptive/traditional house design allow for occasional errors or deviations in construction without overly compromising the safety of the structure. This is in sharp contrast to non-residential construction, where an engineer has designed every aspect of the structure, and the performance of the building is dependent on builders following design drawings exactly. "It appears that the persons marketing wood do not appreciate the huge difference between the regimented use of steel and concrete construction on the one hand and the free-for-all construction of wood."



OUR INTERPRETATION

Although construction is one of the largest industries in North America, it is not a strong employment draw. Poor pay, outdoor working environments, physically demanding work and variable employment scenarios are the dominant reasons, along with a social stigma against the trades in general. Construction is already plagued with a serious lack of an adequate workforce, especially skilled workers, and this is expected to get worse (5). Over the past few years, popular business media and construction trade journals have repeatedly highlighted what they consider a severe and growing labor shortage and labor skill problem. While

this problem affects construction in all materials, comments from designers suggest it is most strongly felt in the wood trades.

The skill of the individual laborer is of concern with respect to structural design because this affects the ultimate performance of the structure and is thus a factor in risk management from the perspective of the structural engineer. If construction workers in wood are seen by an engineer as inadequately skilled, this can inhibit the engineer's willingness to design in wood due to lack of confidence in adequate execution.

Formal training in the construction sector is difficult to accomplish for several reasons. Very few construction firms are large enough to have developed training procedures that would be considered standard industrial personnel practice in other sectors (16). Because of the cyclical nature of the construction industry, employment structures are fluid. This, along with the poor appeal of construction as a career choice, leads to a high degree of transience in the labor pool. The best and brightest tend to jump out of construction as soon as possible. This raises two questions – how can training programs *reach* a transient labor pool, and how can training be *retained* when transience is high?

A variety of **new training and certification activities** have recently emerged within the construction industry as a response by the industry itself to solve the problem (11, 14). Perhaps over time these efforts will additionally prove helpful in recruitment, however, in

COURTESY BRITISH COLUMBIA INSTITUTE OF TECHNOLOGY

BEST BET: PRE-FABRICATION

COURTESY G.K. MARSHALL

Construction quality and cost effectiveness may be improved with the use of pre-engineered, pre-fabricated assemblies in place of site work. Manufacturing benefits include a controlled indoor environment, the ability for round-the-clock production, and better employee retention. Pre-fabricated systems appeal to users because they make an engineer's job easier, and they make on-site construction faster. This is an attractive value-added industry for wood product suppliers.

the short term, the question still remains regarding the ability to draw people to construction vocations and to retain trained individuals. The wood industry should participate in improving the skill level of those individuals constructing in wood, but should consider a variety of avenues for doing so. For example, **prefabrication of wood systems** is a value-added wood industry extension that also offers a more attractive factory career than outdoor on-site construction.

In addition to training the hands-on laborer, **educating the general contractor** will also benefit the wood products industry. A large contractor has access to tradespeople skilled in any material. However his own knowledge and experience might lay with a particular material and this can be a major factor in selection. "More and more work comes with a contractor attached...they tell you what's cheapest for them to build and that's the way it usually ends up." Non-residential builders are generally more sophisticated than residential builders (although this is changing, at least among the largest homebuilder companies), which presents an opportunity for better communication between builders and suppliers.

"I would spend my money on education and qualification of framers."

"An institutional project is not just a big house."

"Contractors need more specialized knowledge of multi-story wood construction."

"Educate contractors in proper use of engineered wood and in structural concepts."

4 DESIGNER SUPPORT

WHAT THE DESIGNER IS SAYING

Most architects and engineers learned little or nothing about wood in school, and once on the job, they have minimal exposure to continuing education in wood and often have had little hands-on contact with new wood products. "Many practicing architects have very little knowledge of wood in general." While claiming to be familiar and comfortable with wood in general, designers cite a need to "increase awareness" of products and applications relevant to non-residential uses of wood. Engineers think the architects need more training, and architects think engineers need more creative inspiration.

Information support while on the job is a widely cited problem: "Distribute more and regular product information to architects, structural engineers and designers." Design professionals want product literature, case studies, design guidelines, cost information and so forth. These materials may exist but are not always known to designers, and access can be frustrating: "There doesn't seem to be ONE agency you can go to." This is in contrast to the activities of competing material industries, which, in many regions, are reported to do a better job of maintaining contact with designers. Specific tools or resources to help in design tasks are particularly necessary: "Provide design aids to engineers, just like other industries. The more information they have, the more comfortable they are with using a particular product."

OUR INTERPRETATION

Although three-quarters of architects and engineers state that they feel comfortable designing non-residential buildings in wood, other comments from them suggest otherwise (3). When asked to explain why wood is not used more in their design practice, architects and engineers frequently highlight a lack of personal experience, a lack of product knowledge, a lack of training, and a lack of design resources in wood – all of which are important factors in design comfort. This apparent contradiction can be explained by clarifying the difference between general comfort with the material (i.e., everyone is more or less familiar with wood) versus the detailed knowledge

What designers want:

"More design data."

"More user-friendly design guides that apply to all manufacturers (standardization)."

"Provide standard connector info with wood products."

"Better cost information."

"Easy design tools."

"Better catalogues."

"Help with code compliance."

"Information on the capabilities and applications for new products."

"More hands-on contact with actual products."

"Short courses on advanced design."

that comes from regularly designing with wood, and in particular, familiarity with wood in a non-residential context. Most designers probably feel that wood is not complicated, but their comments suggest that they do not possess an adequate tool kit to easily work with wood. Designers need better support in wood: more exposure, more pre- and post-professional training, and more on-the-job tools. This will improve familiarity, knowledge, comfort, ease and skill regarding wood in non-residential structural applications.

The building blocks for experience begin with **university education**, where wood courses are scarce. Because architects and engineers aren't formally exposed much to wood in school, they may begin their careers with a bias for steel and concrete. There is a "seriousness" accorded steel and concrete, while wood is ignored as the low-tech, vernacular material used for smaller, non-engineered structures (8). More pre-professional formal training might help increase the use of wood in non-residential buildings, but to what degree is uncertain. A more immediate effect would probably result from greater attention to the needs of the practicing professional. However, greater exposure to wood in school will establish interest and inspiration early. Establishing early experience is critical; the more that designers – particularly structural engineers – work with a particular material, the more they are locked into a pattern: "I have spent 20 years gaining experience in steel construction. And for that reason, I design primarily in steel."

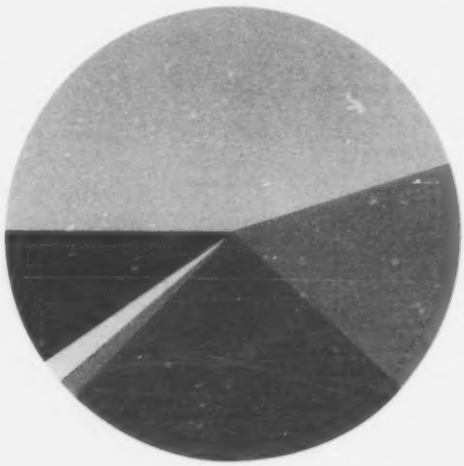
Designers do much of their learning on the job and are more focused in their need for information once

BEST BETS

- **Facilitate greater distribution of existing design tools and adjust those tools, if necessary, according to designer suggestions.**
- **Specific guidelines needed: code compliance, sprinkler design, seismic and hurricane design, design for buildings higher than two storys, durability design.**
- **Develop more continuing education courses in wood.**
- **Sponsor more wood design courses in architecture and structural engineering schools.**
- **Sponsor more design competitions, scholarships, exhibits and evening lecture series in wood design.**
- **Develop a one-stop shop for all information on wood (e.g., a web site).**
- **Increase the extent of information in product literature.**
- **Create more visibility with designers through office visits, advertising, and so forth.**

WOOD DESIGN TRAINING IS WEAK

A total of 72.5% of North American architects and engineers learned little or nothing about wood in school (3).


Learned a little but needed more 45.0%
Learned a little but it was enough 16.3%
Learned a lot 24.0%
Learned too much 1.25%
Other 2.3%
Learned nothing 11.2%

"I didn't have any courses in wood. They were electives. The major courses were in steel and concrete."

in practice. **Continuing education** is perhaps a more efficient place to direct educational resources than primary education, where some of the pool may not end up in design practice. Designers also need to keep up to date: "Your school education is a good start, but it doesn't last long." Many licensing jurisdictions for architects and engineers require continuing education units, so there is an inherent incentive in the specifiers' infrastructure for continuing education, which can easily comprise wood courses. However, the busiest designers – the most valuable ones to influence – have little time to spend on education. Events have to be concise, focused and appropriately scheduled: "Offer seminars in evenings, lunchtime and Saturdays."

Designers express a need for good **design tools** – software and guidelines that simplify their work. Existing design manuals may not be aimed at optimizing the engineer's time. This is complicated by the increasing complexities of wood design as it develops a stronger technical foundation: "We've gone from allowable stress design to limit states – that makes it even more difficult for engineers who aren't proficient in wood design."

Designers want better **product literature**. Standardized product properties (to enable comparison between different products), cost information, and application guidance such as the inclusion of standard design details and shop drawings are all desired. Well-informed and highly visible sales representatives are a crucial link in the communication between product manufacturer and specifier.

Accessibility of product information and design support is critical. Manufacturers need to get information to the busy professional quickly and easily. Creation of a "one-stop shop" for all wood design information would be helpful. Regular visits to design offices and exposure through professional association mail inserts, direct mail, free delivery of wood design magazines and better use of the web are methods for bringing the information to the designer rather than making the designer go searching. An aggressive effort to stock most offices with current wood design manuals would help.

"Workshops are very effective."

COURTESY CANADIAN WOOD COUNCIL

"I think the wood industry has improved a lot. The shop drawings have improved and they offer design assistance to consultants."

COURTESY CANADIAN WOOD COUNCIL

DESIGNER RESOURCES

Support materials exist, but perhaps not enough designers have them.

5 WOOD'S IMAGE

WHAT THE DESIGNER IS SAYING

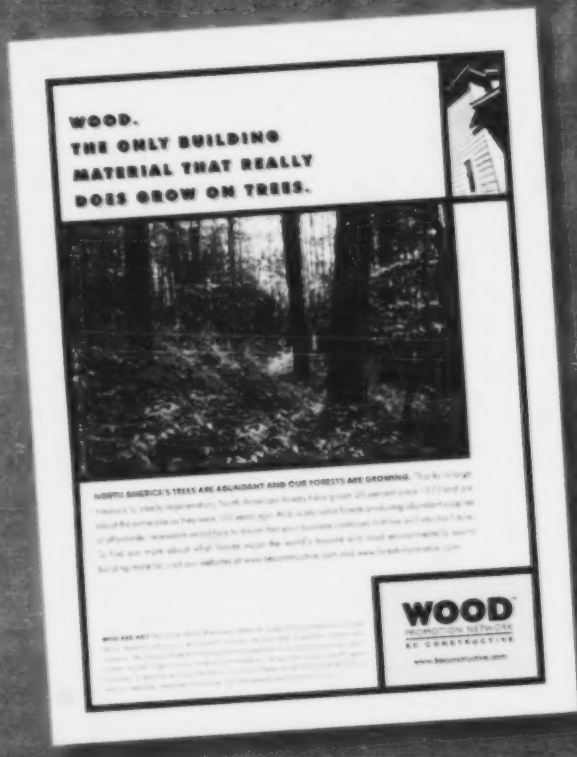
For many non-residential projects, wood is never given fair consideration for a reason more fundamental than code restrictions or costs: it is not seen as appropriate: "Wood has its place." Cultural associations with wood, poor perceptions of wood's attributes, and entrenched traditional practices all work against a favorable image of wood for non-residential buildings. This is a wood image problem that requires addressing with architects, engineers, builders, owners, building officials and the general public. The negative perceptions of wood are in sharp contrast to wood's alternate characterization as a premium finish material or a high-end structural system when used aesthetically in exposed timber buildings. These niche uses are not the issue at hand; the image problem is in the category of every-day non-residential buildings.

OUR INTERPRETATION

The comments from architects and structural engineers reveal how strongly perceptions of wood have an influence on its use. Negative **perceptions** can rule out the use of wood before design even begins; can influence the development, application and interpretation of codes, other regulations and standards; and can strongly affect the attitudes and general approach of the design team to wood, even when it is selected. Typical image problems for wood include perceptions that it is: low-tech; poor quality; not strong; not appropriate for non-residential buildings; the cause of deforestation; too conducive to burning and rotting; and too hard to design with.

Addressing these misperceptions would best begin with an acknowledgement that some building applications are truly not appropriate for wood – a promotional effort should not be attempted in cases where wood really isn't a good fit or where wood is too strongly resisted. Such an effort is not only wasted but carries a risk of backfire and backlash if wood is used anyway and fails to meet expectations.

However, many of wood's image problems are undeserved and can be solved if we understand the



The delicate issue of forestry concerns and influence on the wood products market is being tackled by the Wood Promotion Network and other organizations.

problem from the perspective of the user and strive to correct the misperceptions in the appropriate language. Misconceptions about wood's fire, structural and durability performance are understandable when the public only has historical myth and intuition as information sources regarding the properties of wood systems. This problem is perhaps best countered with **credible performance data**, published with a recognition that some perceptions have an emotional component as well – forestry concerns, most notably.

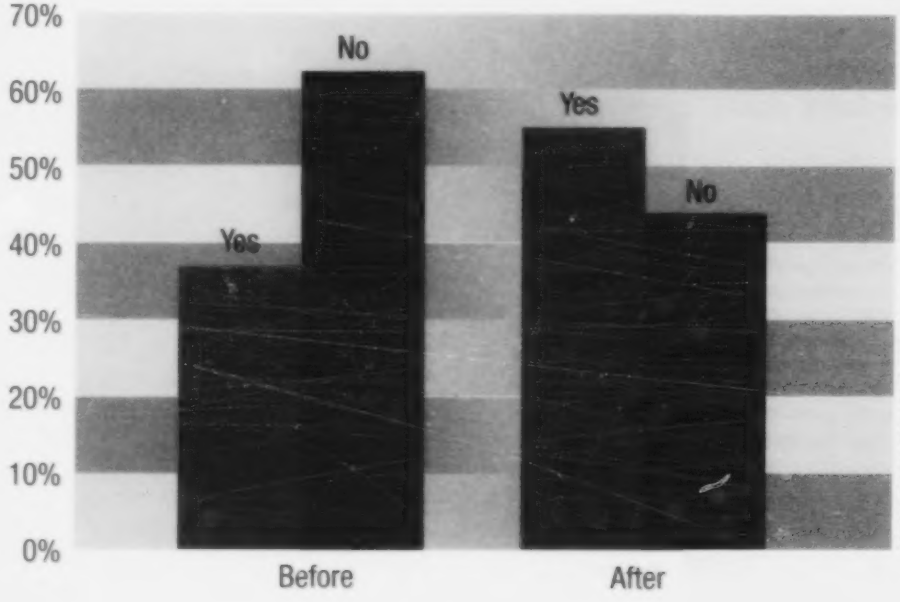
Publication needs to take a variety of forms depending on the target audience – for example, technical details may be best for designers, and soundbites woven through popular media may work for the general public. **Market research** would uncover hot buttons and effective information routes for each of the various societal segments being targeted.

There is a need to further develop the dual personality of wood: it is used in both low-cost, simple products and high performance, engineered products. The challenge for wood product manufacturers is to maintain the beneficial low-tech image of wood in residential construction (which enables inexpensive construction and the large DIY market), while **developing a high-tech image** in the non-residential sector. This will involve clever manipulation of perceptions and perhaps development of products and systems targeted only for non-residential construction to differentiate a separate class of wood products. Alternatively, the wood products industry might choose to disregard all but the lowest end of the non-residential market, in which case wood can continue to be marketed solely on price.

MARKET INTELLIGENCE

For wood producers seeking to increase wood use in non-residential construction, focused market research is vital, not only in North America, but in other wood-friendly regions of the world like Europe and Japan. Information on specifiers' attitudes and needs is necessary in order to develop tailored promotional campaigns. In addition, information on the non-residential marketplace is useful in setting realistic market share goals and in establishing monitoring processes to ensure that these benchmarks are being met.

It is important to recognize that increasing share in the non-residential marketplace is no easy task. Given the current poor market share of wood in this sector, the marketing problem is not unlike being a new entrant into a foreign market that has a predisposition to using building materials other than wood. Wood products can't simply be pushed onto the market in an environment like this. In some ways, this represents a paradigm shift for forest product companies accustomed to moving commodity goods out the door to downstream customers. In an environment where the customer does not have an inherent preference for the product, a clear understanding of the customer is required. In fact, market information should become more prominent in driving wood product R&D to combat rising competitive pressures in all construction sectors.



BEFORE AND AFTER A PUBLIC AWARENESS CAMPAIGN:

"Do you think the use of wood to construct commercial or public buildings four storys or less should be encouraged and promoted?"

PHOTO BY PRAKASH PATEL, PRINTED WITH PERMISSION OF CANADIAN WOOD COUNCIL

BEST BETS

- **Publish detailed case studies of: cost effectiveness, code-compliance examples, and applications in various building types.**
- **Get the facts out on wood performance in: fire, seismic, hurricanes, longevity, environment.**
- **Use glossy design journals to inspire designers and to reward wood designers by publishing their work.**
- **Develop direct-to-consumer advertising for building owners and the general public.**
- **Promote wood as the ideal small building/light-frame solution.**

THE POWER OF EXAMPLES

Published design projects — especially if carried out by third-party design journals or the popular press — are effective free advertising that additionally can inspire and inform the marketplace. Frequent publication of various wood applications helps develop the idea that wood is "normal" in non-residential buildings. Readers gain a broader appreciation of the possibilities of the material — for example, this project conveys the sense that an exposed timber structure was achieved simply and perhaps inexpensively, while also delivering a particular sense of place.

Project: *Chapel for the Methodist Board of Child Care, Baltimore, Maryland*

Architect: *Kerns Group Architects*

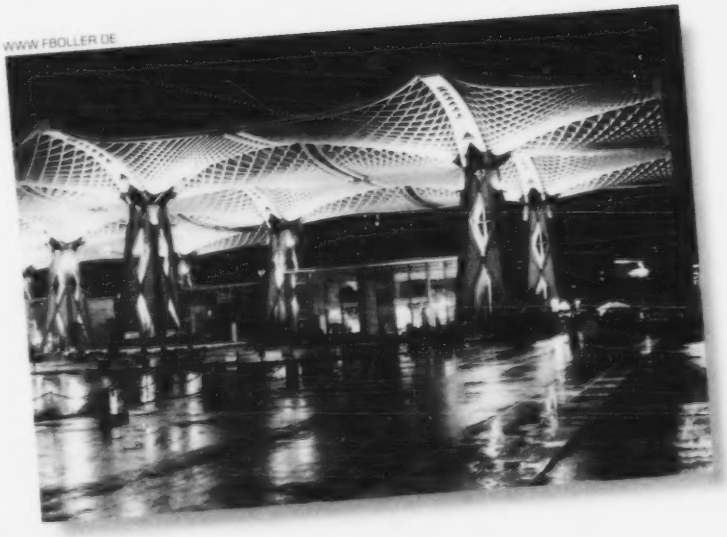
BUT...

USE SHOWPIECE PROJECTS WITH CAUTION

The spectacular permanent roof over a plaza at Expo 2000 in Hannover was constructed in wood. Demonstrations like this help raise awareness and appreciation of wood, but may not have a significant effect on wood use because this structure appears costly. In fact, wide promotional use of custom, innovative wood design examples over more mundane buildings may reinforce the perception that long-span engineered wood buildings are exotic and expensive.

Architect: *Thomas Herzog*

Engineer: *Julius Natterer*



WWW.FBOLLER.DE

Promotional efforts should take greater advantage of wood's special stature as an aesthetically pleasing material when exposed. No other structural material enjoys the highly valued **aesthetic attributes** of wood such as beauty and warmth. However, the cost premium for attractive heavy timber structures restricts this use to a niche market. There is likely a ready market on the basis of aesthetic appeal if the price were lower. This presents an incentive to attach a stronger aesthetic image to lower cost products. For example, inexpensive pre-manufactured trusses would have more appeal to designers if the connections were resolved in an attractive manner. A corresponding advertising campaign would aim to transform the crudely utilitarian image of this product.

One challenge is overcoming the view of wood as inappropriate simply because it may not be the traditional choice for many non-residential applications – this is a battle against **industry inertia**. The building industry is change-resistant for good reason: high price of failure, low profit margins, and tight schedules are all inhibitors to innovation or other deviations from standard practice. "In my opinion, wood use does not need to increase." "Contractors have the 'I never did it this way before' mentality." An extended period of promotion to, and a rewarding of, the innovators is needed to break this precedence.

Changing the tide:

"Use case studies – if you cannot demonstrate that it's been done, no one will take you seriously."

"More information on systems that can work and cost comparisons."

"I believe that changing public perceptions on the use of engineered wood in commercial and institutional buildings is the primary task."

"Market a new aesthetic using engineered wood products as an honest, finished material."

"Change client (i.e., public) perceptions: wood is safe in a fire or earthquake, wood is durable and long-lasting if properly detailed, wood is reasonably economical yet can add prestige, wood is a 'green' material, energy saving and healthy."

"Change perception of environmental impact."

"Insurance companies need to be educated."

"It would be GREAT if wood structures were better promoted."

PHOTO BY PRAKASH PATEL PRINTED WITH PERMISSION OF CANADIAN WOOD COUNCIL

RIDE THE GREEN WAVE

Often identified as the greenest office building in the U.S., this project uses the common design technique of exposing structural wood to reinforce a message of environmental responsibility. Wood's image as a natural material is a marketing advantage, if handled carefully and subtly.

Project: *Chesapeake Bay Foundation Headquarters, Annapolis, Maryland, completed 2000.*

Architect and Engineer: *SmithGroup*

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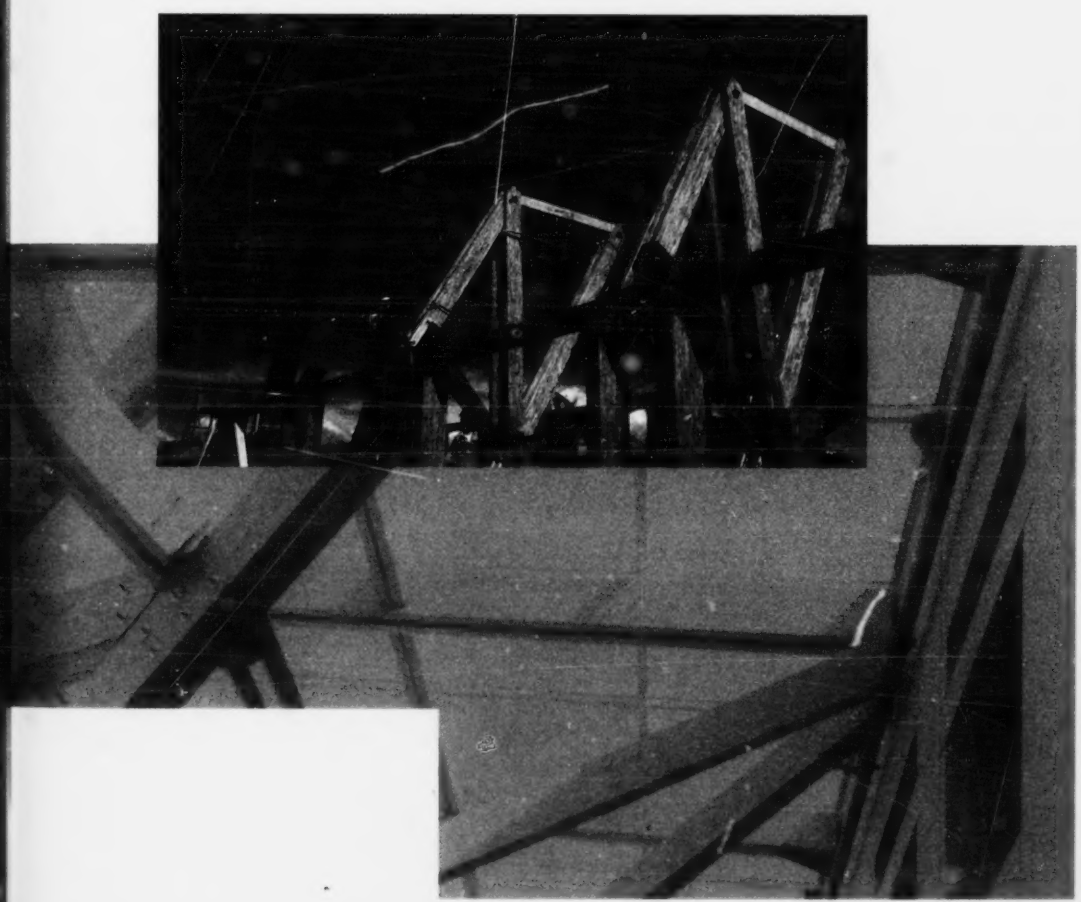

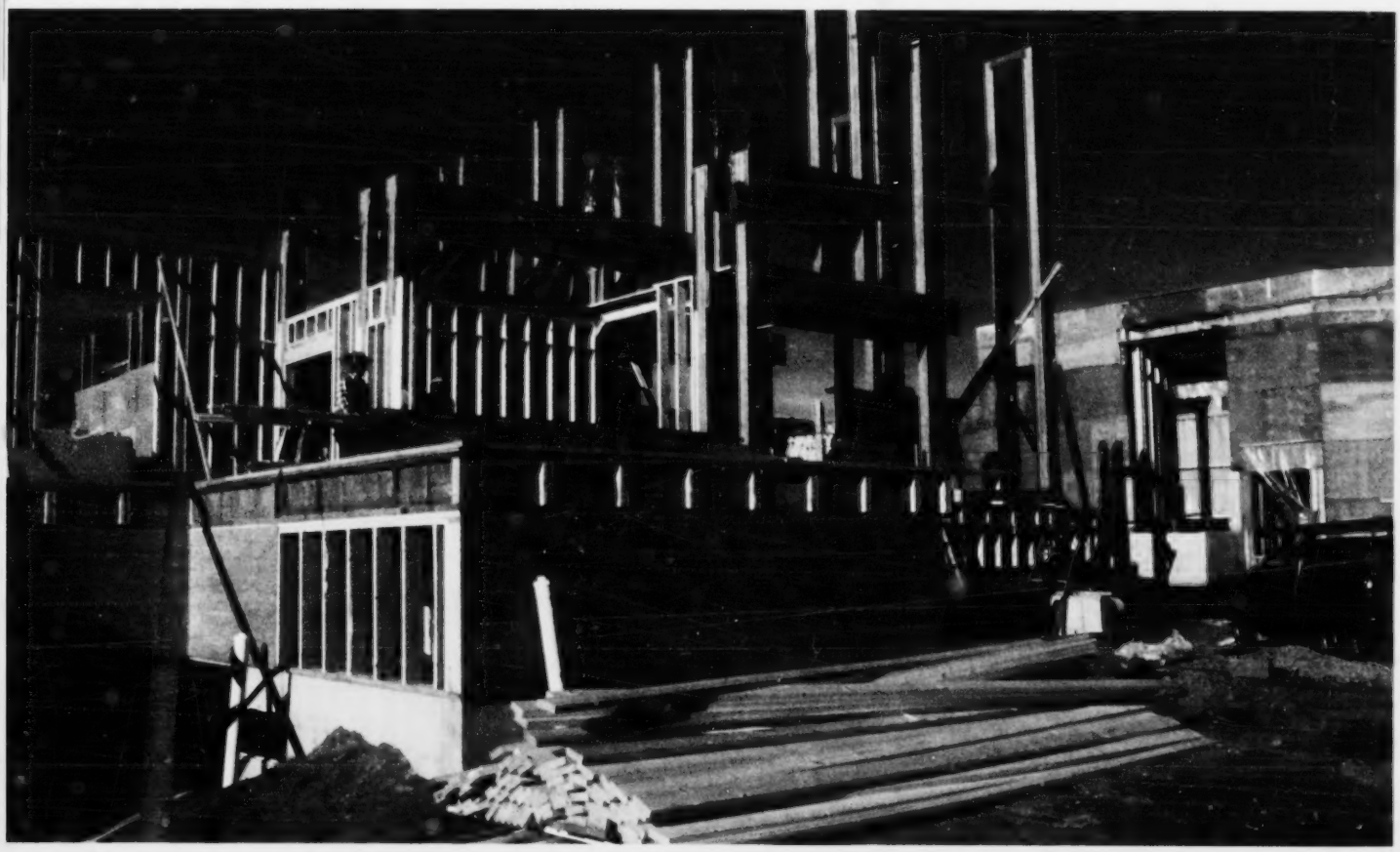

This 109,000 ft² (9,800 m²) wood products research facility houses office, laboratory and industrial activities and was completed in 1990. The structure is wood-frame.

Project: *Forintek Canada Corp., Vancouver, BC*

Architect: *The Hulbert Group*

Structural Engineer: *Jones Kwong Kishi*

PHOTO BY ROGER BROOKS PRINTED WITH PERMISSION OF CANADIAN WOOD COUNCIL

This heavy-timber atrium is part of a 240,000 ft² (21,500 m²) university building with laboratory, office and classroom spaces and with approximately 50% of its structure framed in wood. The building was completed in 1998.

Project: *UBC Forest Sciences Centre, Vancouver, BC*

Architect: *Dalla-Lana Griffin Dowling Knapp*

Structural Engineer: *CWMM Consulting Engineers*

Timber Contractor: *Timber Systems*

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